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DMS - a promising concept for islands: "Integrated Resource Planning (IRP) for the island of Crete"

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Energy Services & DSM

SESSION VI / Lecture 9

INTEGRATED RESOURCE PLANNING FOR THE ISLAND OF CRETE

1. Assessment of Existing Situation

The development of the electricity as well as the overall energy sector of Crete needs to go through a revolutionary reform. The fast crowing economy, mainly the commercial and service sectors impose a great demand for electricity and petroleum products.
This study aims towards the assessment of the economically and environmentally feasible options that could contribute towards the development of the electrical power system of the island. The assessment of all supply and demand side options is performed based on an Integrated Resource Planning (IRP) methodology.

2. Supply Side Power System Expansion

2.1. Conventional Supply Side Options

The base case reference scenario incorporates the introduction of oil fired units that may be installed in the existing power stations as an extension, such as the case of the Chania station or at new sites that have been agreed with the regional authorities such as the case of Atherinolakos. It is important to note that that at present the system is in need of new generation while the commissioning of two new gas turbines is not adequate for economic operation of the power system. The basic parameters of these supply side options are as follows:

New Gas Turbines Under Construction
Two new Diesel oil fired gas turbines 59 MW each are presently under construction in the premises of the Chania power station. The first unit is expected to be commissioned in 1998 and the second in 1999. These gas turbines may later be converted into a 2 + 1 combined cycle unit with the addition of a 60 MW steam turbine.

Fuel Oil Fired Diesel Engines
A medium term supply side option is the commissioning of a relative small number of fuel oil two stroke Diesel engines in the capacity range of 30 MW. These units will have to be constructed on the new site at Atherinolakos with an earliest commissioning date of 2000.

Fuel Oil Fired Steam Units
One of the most promising long term options for the island of Crete is the introduction of fuel oil fired steam units in the capacity range of 75 MW.

Pumped Storage Units
It should be noted that this option is only considered in conjunction with high level penetration levels of wind power generation to overcome the time dependency problems. The pumped storage unit under consideration is a project that has been identified by PPC in the Chania prefecture. The project under consideration incorporated three 15 MW units.
The options presented are evaluated in detail through the generation planning methodology incorporating two computer programmes (WASP III and COST).

2.2 Supply Side Options Based on the Introduction of Natural Gas

An alternative to the use of fuel oil for power generation on the island of Crete is the introduction of LNG. However the undertaking of such projects needs to undergo detail study from a technical, operational as well as commercial point of view. In the study herein LNG is considered as an alternative to the fuel oil and is examined mainly from the economic point of view. A basic parameter of the LNG project's technical feasibility is the existence of an appropriate area for the installation of a liquefied natural gas terminal. For the purpose of this study, scenarios have been formed for the introduction of natural gas in the energy system of Crete, according to the location for the installation of a liquefied natural gas terminal and the use of natural gas to end consumption.

According to these criteria, two scenarios are formed:

Scenario 1	The case of using natural gas for electricity production, by supplying it from Algeria. A common vessel is used for the transfer of liquefied natural gas to Crete and Revythousa for the mainland natural gas network. This scenario considers that the liquefied natural gas terminal will be constructed at the Corakies site.
Scenario 2	Same as scenario 1 but the liquefied natural gas terminal will be installed at the at Atherinolakos site without supplying the rest of the island.

With respect to scenario 1 a number of existing units are converted from Diesel oil and fuel oil fired to natural gas. It should be noted that all calculations presented herein with respect to natural gas assume a fuel price based on international prices and on the contract that DEPA already has for the Algerian LNG.

2.3 Supply Side Power System Expansion Scenarios

In the study herein proposals are made for the rationalisation of the electricity energy balance on the island and for the minimisation of the production cost in the sort, medium and long term.

Two basic supply side expansion scenarios are considered and analysed:

Conventional Scenario	Considers supply options: Fuel oil fired Diesel engines, fuel oil fired steam units, Diesel oil fired gas turbines and their conversion to combined cycle units.
Natural Gas Scenarios	a. Considers a liquefied natural gas terminal at the Korakies site, conversion of the existing power stations to natural gas fired and the installation of new natural gas fired combined cycle units.
	b. Considers a liquefied natural gas terminal at the at Atherinolakos site without supplying the rest of the island and the installation of new natural gas fired combined cycle units at the Atherinolakos site.

The power expansion scenarios are evaluated with the help of the WASP III and the COST models. The three scenarios are evaluated for their economic feasibility and their security. The scenario that appears to be the most realistic and economic feasible is considered as the reference scenario for the evaluation of the DSM and the renewable energy options.

2.3.1 Power Expansion Investment Requirements

The investment requirements for the aforementioned supply side expansion scenarios for the power system of Crete are presented in Figure 2.1. As it can be observed the conventional scenario and the LNG - b scenario are almost equivalent.

In order to compare the investment requirements of the three supply side scenarios on a common base, it is necessary to compare the cumulative present value of the investment cash flow schedule. Figure 2.2 present the cumulative 1998 present value of the investments taking into account that the real discount rate is 10% per year.

As it may be seen the investment requirements in present value terms of the LNG-a scenario are almost twice the value of the other two scenarios and it is unlikely whether the natural gas sales to other consumers can offset the additional investment requirements.

In addition, the LNG-b scenario is 5,2 billion drachmas more expensive than the conventional scenario. However, it should be mentioned that the cost estimates of the LNG terminal might be overburden considering that they are only preliminary estimates.

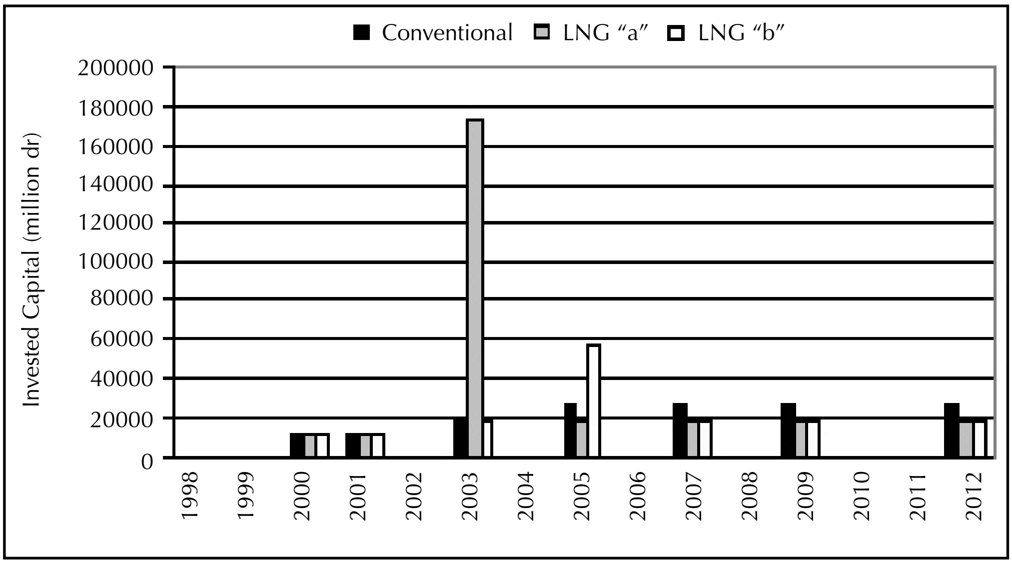

Figure 2.1. Power System Expansion Investment Requirements (constant 1998 prices)

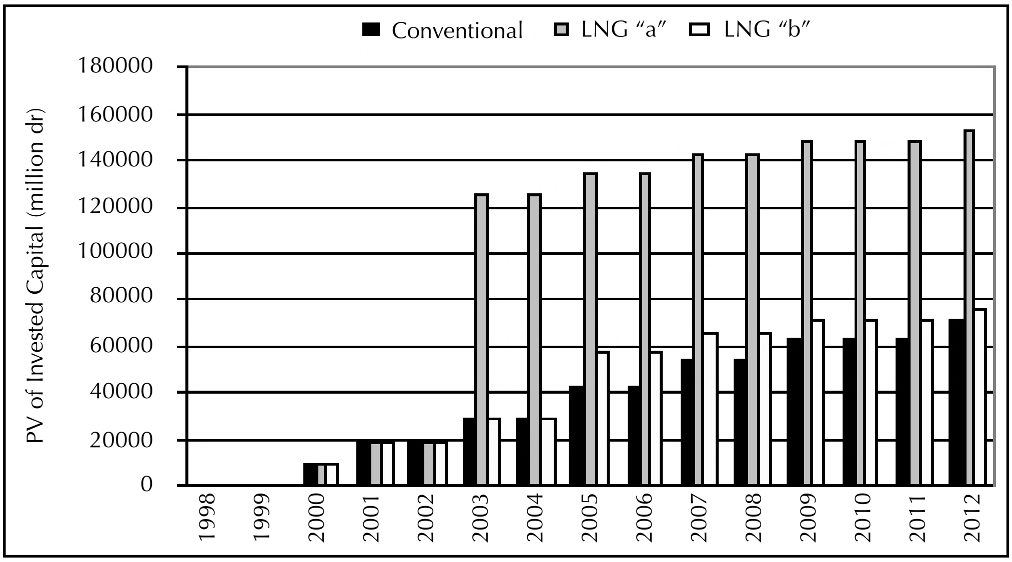

Figure 2.2. Cumulative Power System Expansion Investment Requirements (1998 present value)

2.3.2 Evaluation of Supply Side Power Expansion Scenarios

The evaluation of the supply side scenarios is carried out utilising the minimisation of the overall system cost Net Present Value (NPV) criterion. The real discount incorporated throughout the planning horizon is 10%. The cost that are accounted for are:

o Capital costs (investment and salvage value of investments)

o System operating costs (fuel, operating and maintenance, and unserved energy cost to account for system reliability costs)

It was observed that the NPV of the conventional scenario and the LNG-b scenario is almost negligible (66 million drachmas in present value terms for a 30 year period). On the other hand, LNG-a scenario is almost 71,5 billion drachmas more expensive than the conventional scenario and therefore will not be considered further.

Taking into account the uncertainty associated with the siting and investment requirements of the LNG terminal as well as the indifference in overall system development cost, the study considers as a base case reference scenario the conventional expansion with fuel oil fired steam units.

The costs associated with the reference scenario that will be incorporated in the comparison and evaluation of the DSM and renewable energy options have to be expressed in real market prices. Therefore, all fuel cost will include taxes and all other costs are expressed in constant 1998 prices.

Figure 3.3 presents the average annual production cost of the power system on the island of Crete, as it will be developed according to the conventional scenario.

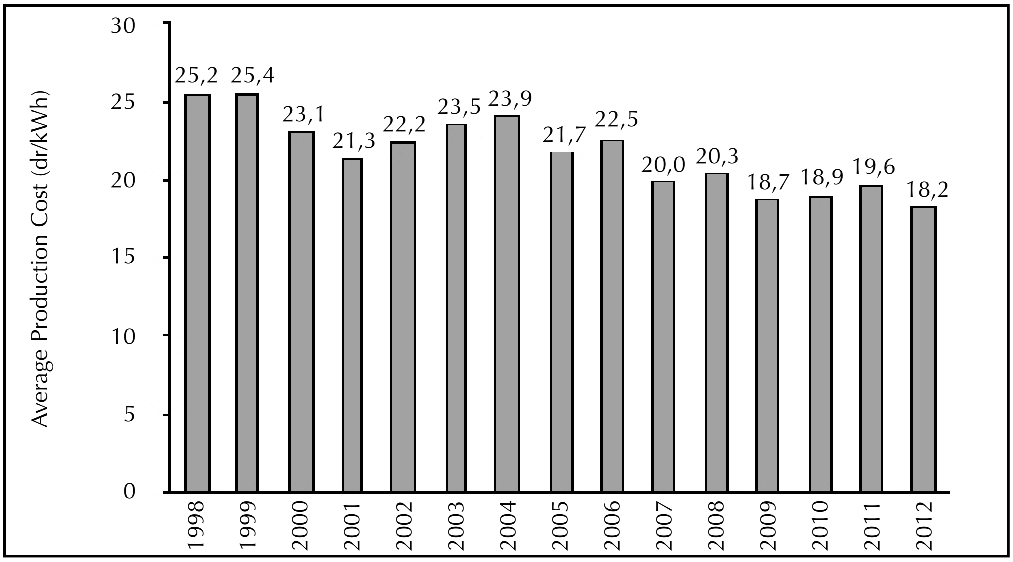

Figure 3.3. Average Power System Total Operating Cost in 1998 constant prices (it excludes capital expenditures)

3. Demand Side Options

Due to capacity constraints, the main concern in the Crete energy system at present is the peak load. As an alternative or complementary action to expanding the production capacity of the system, this chapter presents an assessment of the demand-side management (DSM) potential. A number of large end-uses holding a significant potential for load reduction especially during peak load hours have been identified and investigated. Furthermore, these end-uses represents areas where experience shows that realisation of the potential savings is possible. The selected end-uses are:

o Public lighting
o Residential lighting
o Hotel lighting
o Hospital lighting
o Water and sewage centre pumping.
o Replacement of electric home heating with Diesel heating

4. Renewable Energy Options

The island of Crete offers numerous opportunities for renewable energy applications. The present study considers only mature and economic feasible technologies in order for renewable energy sources to make a considerable contribution to the energy balance of the island. The options under evaluation are: wind parks, small hydroelectric projects, biomass for electricity production, solar heaters for electricity substitution and photovoltaic systems.

5. Integrated Resource Power System Expansion

5.1. Generation System Expansion Impacts

The implementation of a DSM programme and the integration of renewable energy resources will impact the long-term expansion planning of the power system of Crete. The impacts with respect to the generation system will be in the form of new investment deferral, the reduction in operating production cost, improvements in the security of supply. In this section, the demand side options as well as the renewable energy projects are evaluated through an integrated resource planning approach where each option on the demand side is tested and evaluated for its impacts on the power supply system.

5.2 Economic Impacts

The annual investment requirements for the new capacity additions for the conventional expansion scenario in comparison with the DSM programmes and the renewable energy option scenarios are analysed and compared.

5.2.1 Economic Impacts due to DSM Penetration

The DSM options integrated into the expansion plan compete with the conventional production cost and supply generation expansion options. Therefore in addition to the investment requirements, the energy balance and its associated production cost is determined. Figure 5.1 presents the levelised operating avoided cost expressed in present value terms. The high-avoided fuel prices presented in the figure are due to the cancellation of the gas turbine conversion that has resulted from the DSM penetration.

5.2.2 Economic Impacts due to Wind Penetration

Considering the importance of the wind resource for the island of Crete two penetration scenarios are evaluated for their economic feasibility. The first scenario considers the restrictions on wind penetration due to the limitations imposed by the system load characteristics and the operational limitations of the system. The second scenario considers the enhancement of the conventional generation system with a 45 MW pumped storage unit that will assist in improving the system load factor and thus allowing the penetration of more wind parks.

a. Restricted Wind Penetration Scenario

Figure 5.2 presents the levelised operating avoided cost. As shown the avoided operating cost represents the cost value of electricity produced by a weighted average of diesel oil and fuel oil generation.

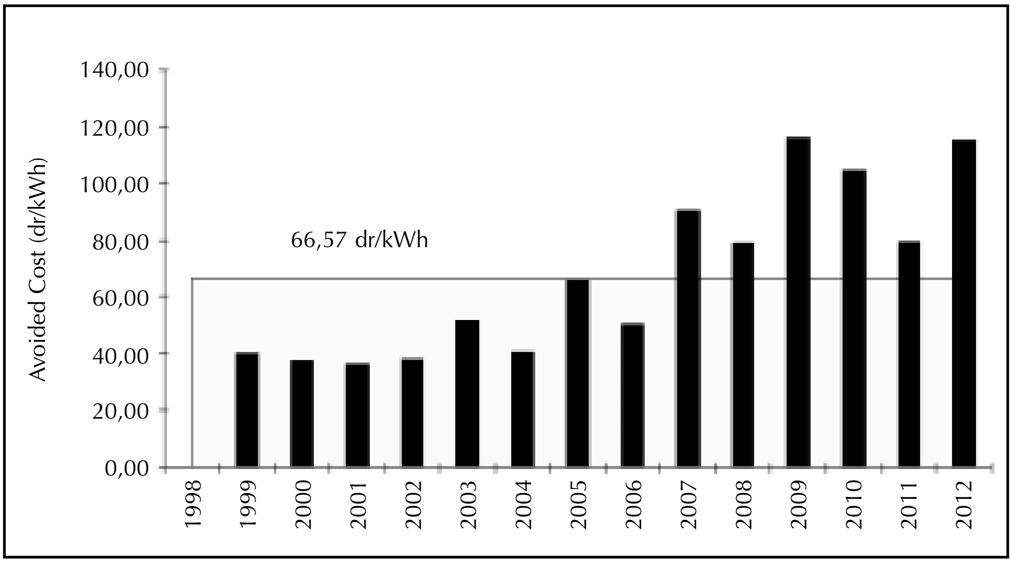

Figure 5.1 Levelised Production Avoided Cost due to DSM Penetration

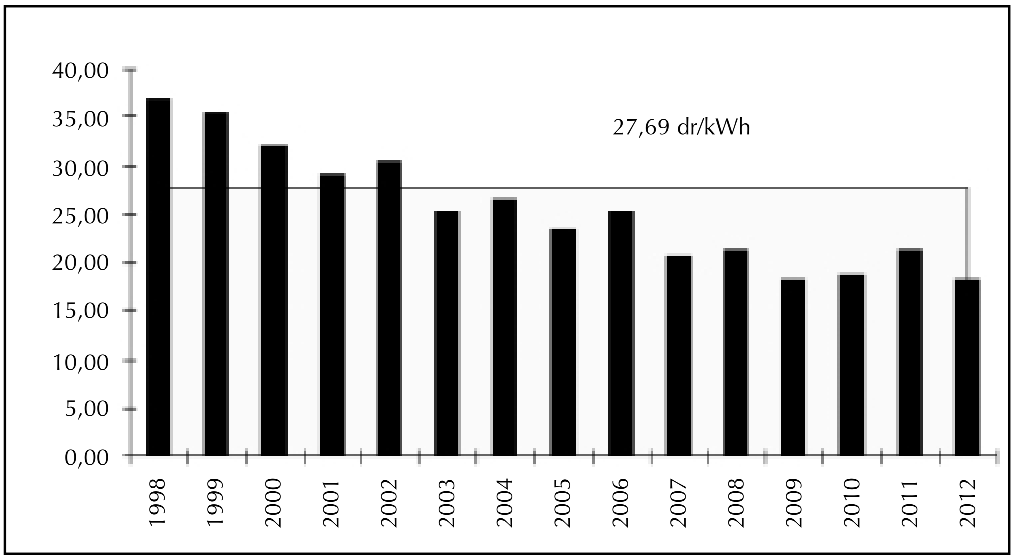

Figure 5.2 Levelised Production Avoided Cost due to Restricted Wind Penetration

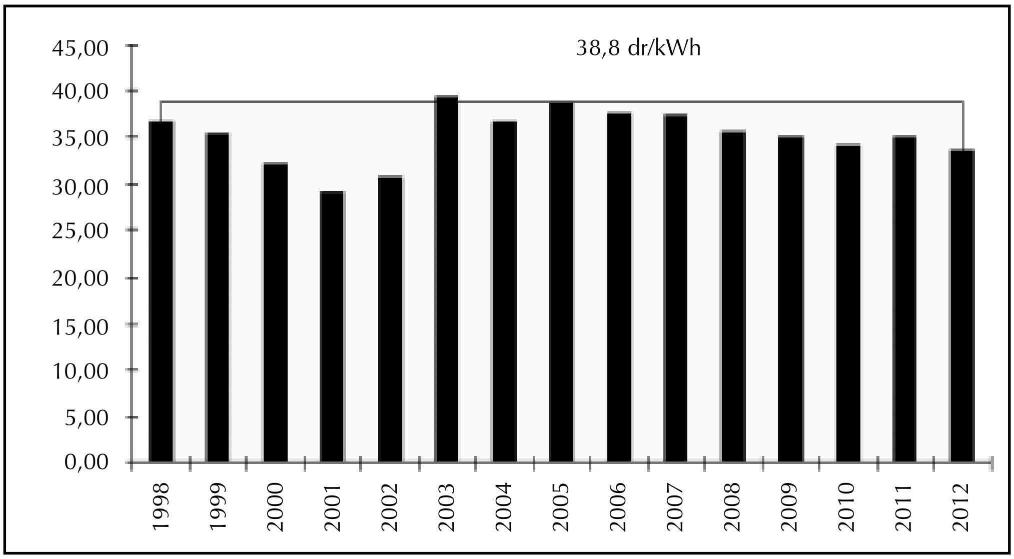

Figure 5.3 Levelised Production Avoided Cost due to Pumped Storage - Wind Penetration

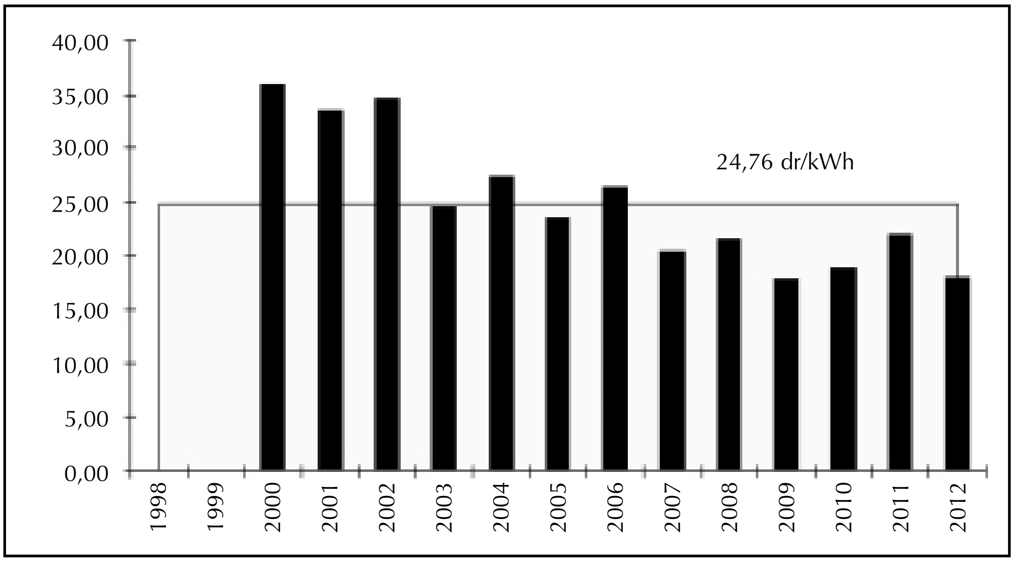

Figure 5.4 Levelised Production Avoided Cost due to Small Hydroelectric Projects

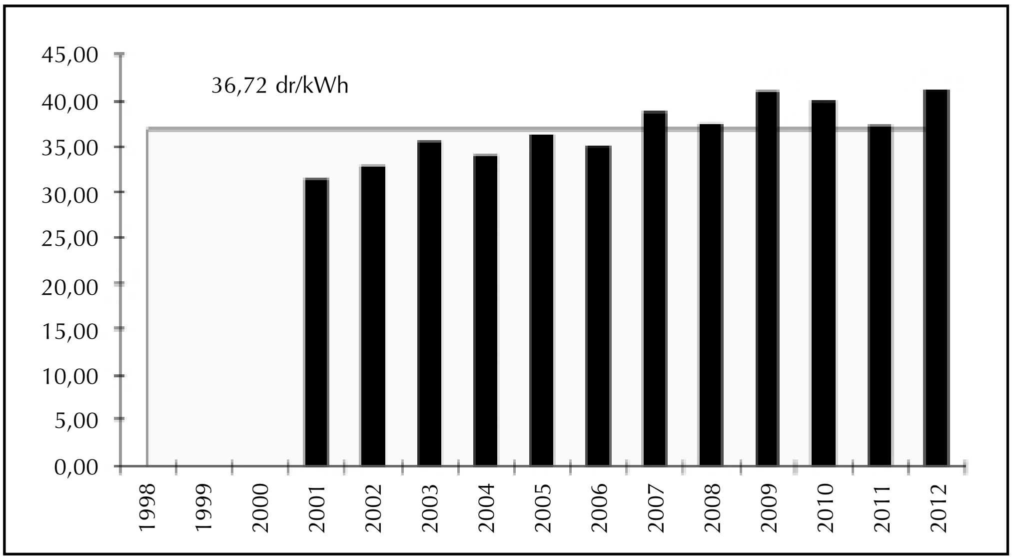

Figure 5.5 Levelised Production Avoided Cost due to Biomass Projects

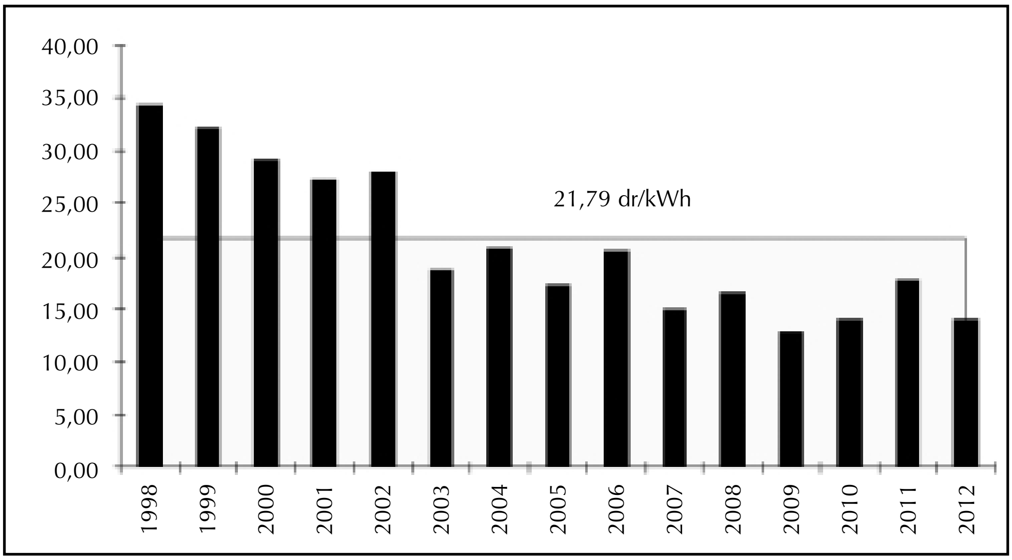

Figure 5.6 Levelised Production Avoided Cost due to Solar Hot Water System Penetration

b. Wind Penetration Scenario Assisted by Pumped Storage Unit

Figure 5.3 presents the levelised operating avoided cost. As shown the avoided operating cost represents the cost value of electricity produced by a weighted average of diesel oil and fuel oil generation. It should be noted that the life cycle levelised avoided cost (38,8 dr/kWh) is higher than the tariff applied to the independent power producers (23 dr/kWh) therefore regardless of plant ownership PPC will benefit in any case.

5.2.3 Economic Impacts due to Small Hydroelectric Project Penetration

Figure 5.4 presents the levelised operating avoided cost due to the operation of the small hydroelectric projects. As shown the avoided operating cost represents the cost value of electricity produced by a weighted average of diesel oil and fuel oil generation. It should be noted that the life cycle levelised avoided cost (24,76 dr/kWh) is higher than the tariff applied to the independent power producers (23 dr/kWh) therefore regardless of plant ownership PPC will benefit in any case.

5.2.4 Economic Impacts due to Biomass Fired Power Generation

Figure 5.5 presents the levelised operating avoided cost due to the operation of the biomass fired generation units. As shown the avoided operating cost represents the cost value of electricity produced by a weighted average of diesel oil and fuel oil generation. It should be noted that the life cycle levelised avoided cost (36,72 dr/kWh) is higher than the tariff applied to the independent power producers (23 dr/kWh) therefore regardless of plant ownership PPC will benefit in any case.

5.2.5 Economic Impacts due to Solar Hot Water System Penetration

Figure 5.6 presents the levelised operating avoided cost due to the operation of domestic hot water solar heaters. As shown the avoided operating cost represents the cost value of electricity produced by a weighted average of diesel oil and fuel oil generation. It should be noted that the life cycle levelised avoided cost (21,79 dr/kWh) is lower than the tariff applied to the residential consumers (27 dr/kWh). Therefore, from the electric utility point of view this option does not appear very attractive.

5.2.6 Utility Life Cycle Economic Viability of Demand Side Options

Based on life cycle economic performance of the DSM and renewable energy options outlined in the previews sections, the overall economic impact to the electric utility may be determined. This impact is expressed in terms of benefit to cost ratio of the net present value savings achieved during the period of the planning horizon and the differential investment requirements with respect to the reference scenario. Figure 5.7 presents electric utility economic impact summary results.
As it may be observed all options demonstrate attractive economic results with the exemption of the domestic hot water solar systems. Figure 5.8 illustrates the effectiveness of each of these options. As it may be observed, the largest economic benefit to the electric utility results from the wind penetration scenario assisted by a 45 MW pumped storage unit. Also, the biomass option demonstrated attractive results, however there is a need for further investigation with respect to the availability and the wholesale cost of the fuel .

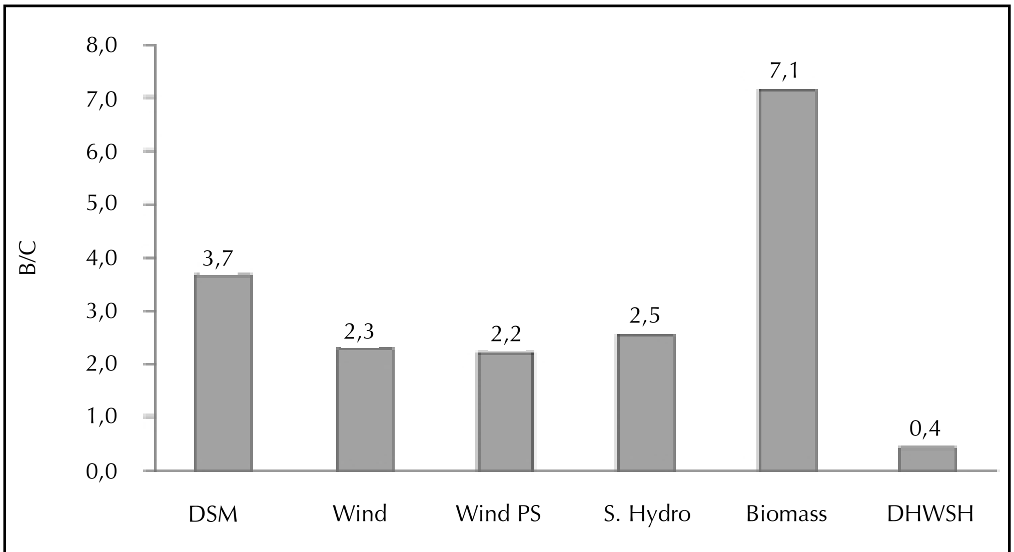

Figure 5.7 Electric Utility Economic Impact of DSM and Renewable Options

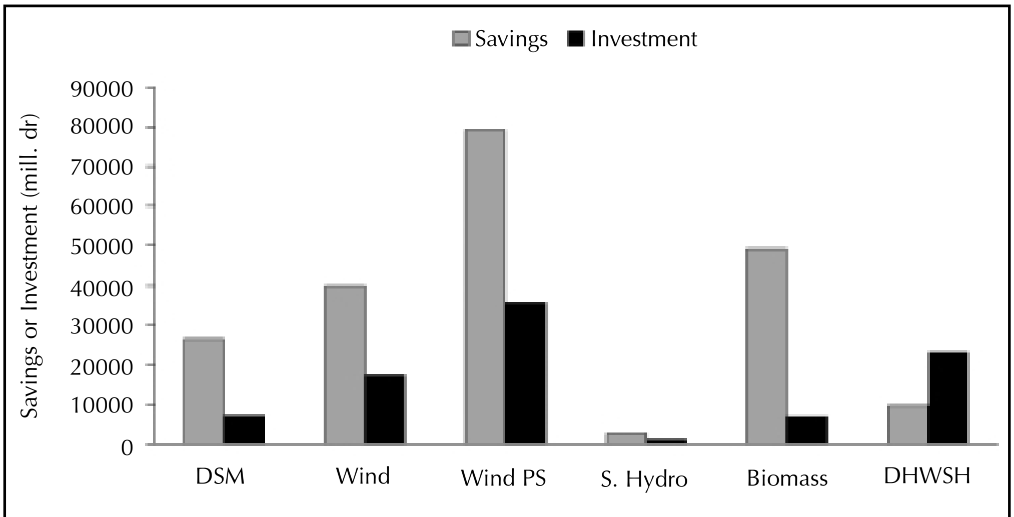

Figure 5.8 Effectiveness of DSM and Renewable Options (in present value terms)

6. Recommendations

The present integrated resource planning study for the electricity sector of the island of Crete will act as a reference point for the development and the implementation of :

- o Comprehensive DSM action plans for various consumer categories and appropriate end use technologies in the field of energy conservation, load management, fuel switching, dispersed electricity generation
- o Promotion of renewable energy forms for power generation and for electricity displacement

However, several issues need to be further addressed in association with the development of a coherent DSM action plan and renewable options support by the electric utility.

DSM Options

It is important to note that further work is required for the enrichment of the end use technologies as well as load characteristics data base so that a better representation of the sectored markets could be achieved. The DSM action, implementation methods and their associated cost need to be clarified further. These parameters impact the decision making of the utilitility to undertake such action plans as well as the end user which most times are reluctant to adopt and comply with technologies and change of consumer behaviour. The factors that need special attention include:

- o product awareness and maturity
- o customer preferences
- o product availability, distribution channels and key influences
- o barriers to acceptance
- o how purchase decisions are made
- o customer expectations in terms of economic performance

Third party involvement (i.e. non-utility and non-customer) could prove to be a driving factor for the accelerated penetration of the particular DSM options. It should be kept in mind that although a DSM programme appears to be cost-effective may not be feasible to persuade the end user to invest in energy conservation since he has other alternative investment with higher rate of return apart from the energy sector.

According to the results presented, it is apparent that the DSM options with the highest consumer acceptance are those associated with immediate electricity savings and this is mainly due to the electricity tariff level and structure. In the long run DSM actions should be stimulated by market forces and not by government mandate. However, given the number of market barriers that exist in the energy market of Crete and the importance of DSM in reducing the overall supply side investments, much greater emphasis should be placed on introducing incentives to the utilities as well as the end consumers for stable co-operation.

Renewable Energy Options

Based on the results, all options are economic viable for the end users and the independent power generators given the tariff structure provided to them through the associated Greek Law 2244/94. However from the electric utility point of view only the power producing options appear attractive. Wind penetration, either restricted or assisted by a pumped storage unit is of profound economic and operational interest to the utility. However, in order to support such high wind penetration levels PPC will have to enhance the high voltage (150 kV) transmission system given that the wind resource sites are not near the consumption centres.

An option for the utility could be to identify the wind resource areas of the island, which are already well known, and to install in strategic geographical locations high to medium voltage substations where the wind parks could be interconnected. Furthermore, the pumped storage option needs to be studied in detail by PPC taking into consideration the impact that it will have to the overall operation of the power system.